ONTARIO WATER RESOURCES COMMISSION

REPORT

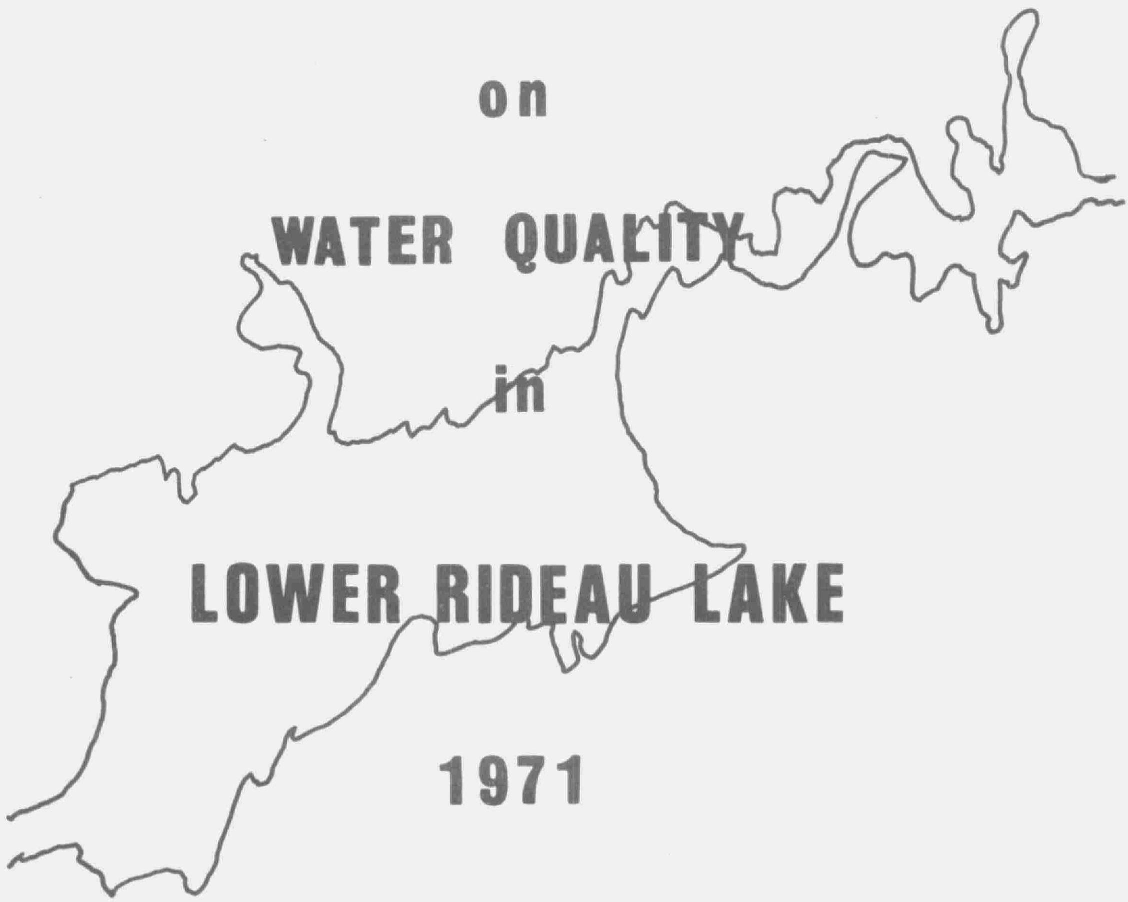
on

WATER QUALITY

in

LOWER RIDEAU LAKE

1971



RECREATIONAL LAKES PROGRAM

BBDD

THE

ONTARIO WATER RESOURCES COMMISSION

REPORT

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IN

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1971

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SUMMARY

A study to evaluate the status of water quality in Lower Rideau Lake was carried out during the summer of 1971.

Lower Rideau Lake lies in the physiographic region known as the Smiths Falls Limestone Plain. This area is characterized by flat topography, shallow soil cover over limestone bedrock and numerous areas of muck. The shoreline around the lake is generally flat with shallow cover. In general, the soil cover is less than the 1.5 meters (5 feet) required by the Ministry of the Environment for the installation of standard subsurface septic tank systems.

In Lower Rideau Lake, only minor temperature and dissolved oxygen differences were apparent between surface and bottom water. The absence of distinct temperature zones with respect to depth and severe deep-water dissolved oxygen depletions indicated the effect of wind-induced vertical mixing processes.

The pH and total alkalinity values were indicative of relatively hard water. Due to thorough mixing of the lake, pH, total alkalinity and free carbon dioxide values were similar at 1 meter below the surface and 1 meter above the sediments. pH values exceeded the criteria for public surface water supplies and recreational use. These high pH values could cause eye irritationto swimmers.

The Kjeldahl nitrogen and total phosphorus concentrations were indicative of an enriched lake which is capable of producing nuisance levels of algae.

The lake due to its shallow, enriched nature was characterized by high densities of algae as measured by chlorophyll a concentrations during the August survey and supported vast beds of aquatic weeds. These plant growths, were instrumental in reducing water quality for recreational use, diminishing the aesthetic quality of the lake and impeding navigation in 1971.

The bacteriological water quality of Lower Rideau Lake was good and generally well within the OWRC recreational use criteria with the exception of Station 16 near Smith's Falls which had a mean of 54 FS/100 ml and exceeded the OWRC FS criteria.

In view of the high nutrient content, algal levels and aquatic weed beds, every effort should be made to prevent any direct flow or leachate from domestic waste disposal systems or other potential sources of pollution from gaining access to Lower Rideau Lake.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Ministry of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Ministry of the Environment in December 1971, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission (now within the Ministry of the Environment) would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes by the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw wastes or septic tank effluents must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths impair aesthetic

values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Lower Rideau Lake in the summer of 1971. Three surveys were conducted; a spring survey from June 11 to 15, a mid-summer survey from August 12 to 16 and a fall survey from October 18 to 22 inclusive. These studies included the assessment of bacteriological, physical, chemical and biological conditions of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Sampling surveys were conducted on an intensive basis (sampling each day for a minimum of five days) which is mandatory for a reliable assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

AREA DESCRIPTION

Geography and Topography

Lower Rideau Lake lies on the boundary line between North Elmsley Township, County of Lanark, and South Elmsley Township, County of Leeds and to the southeast of Smiths Falls.

The lake lies in the physiographic region known as the Smiths Falls Limestone Plain. This area is generally level with a slight inclination towards the northeast and has shallow soil cover over limestone bedrock. The bedrock of the north shore is Potsdam limestone while the entire south shore is composed of Beekmantown limestone.

The soil along the north shore from Rideau Ferry to Stuarts Point is of the Monteagle sandy loam - rock soil complex. This soil complex is a shallow, well-drained soil with frequent bedrock outcroppings. The remainder of the shoreline consists of two basic types of soils. The first type of soil is classified as muck, which is an organic and very poorly drained soil. The areas of muck are: around Stonehouse Point; from the east shore of the Tay River inlet to Sawlog Bay; from Black Creek to Smiths Falls; from Smiths Falls along the south shore to the Poonamalie locks and finally from Bacchus Island to Noads Point. Farmington sandy loam, a shallow, well drained, stony loam till, constitutes the rest of Lower Rideau's shoreline. Generally, the depth of the soil is less than the 1.5 meters (5 feet) required by the Ministry of the Environment for the installation of standard subsurface septic tank systems.

Lower Rideau Lake has water surface area of 12 square kilometers (3,000 acres) with a maximum depth of 6 meters (20 feet) and a shoreline length of 47 kilometers (29 miles).

Climate Range

The Lower Rideau Lake area has a mean annual temperature of 6°C (43°F) and a mean annual precipitation of 86 centimeters (34 inches) including 203 centimeters (80 inches) of snow. The January and July mean daily temperatures are -9°C (16°F) and 20°C (68°F) respectively. According to meteorological reports, the area enjoys over 200 days with no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow provides for participation in most winter sports.

Water Movement

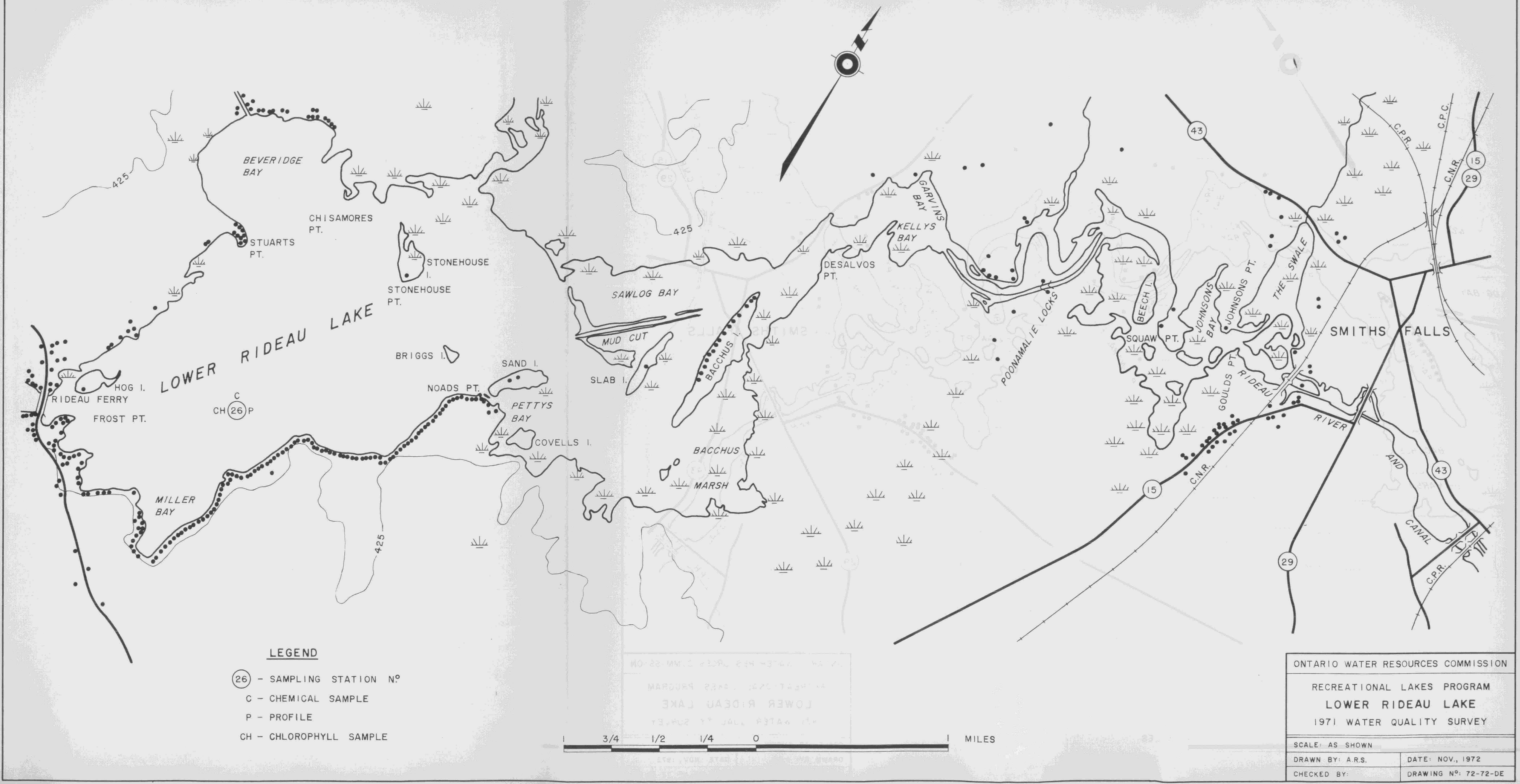
The Lower Rideau Lake and Rideau Canal System from Lower Rideau Lake to Smiths Falls, not including the drainage basins of the Tay River and Black Creek, are approximately 39 square kilometers (24 square miles) in area. Water from this drainage basin flows into the Ottawa River via the Rideau Canal System.

There are five permanent inlets to Lower Rideau Lake and the above mentioned section of the Rideau Canal System. These inlets are: Rideau Lake which enters at Rideau Ferry; the Tay Canal; the Tay River; Black Creek and Bass Lake Jreek. The outlet, located at Smiths Falls, is controlled by a combination of two control dams and lock 31 of the Rideau Canal System. Lake level and outlet volume are regulated by the Federal Ministry of Transport Canals Division.

Shoreline Development

Of the approximate 140 cottages (Figure 1) on Lower Rideau Lake, 60 per cent are located on the south shore from Rideau Ferry to Noads Point. The remaining cottage areas are located from Hog Island to Stuarts Point, from the Tay Canal to Chisamores Point and along the north shore of Bacchus Island. The remainder

FIGURE I


LOWER RIDEAU LAKE
BEVERIDGE BAY
CHISAMORES PT.
STUARTS PT.
STONEHOUSE I.
STONEHOUSE PT.
BRIGGS I.
HOG I.
RIDEAU FERRY
FROST PT.
C
CH 26 P
MILLER BAY
SAND I.
NOADS PT.
PETTYS BAY
COVELLS I.
SAWLOG BAY
MUD CUT
SLAB I.
BACCHUS I.
BACCHUS MARSH
DESALVOS PT.
GARVINS BAY
KELLYS BAY
POONAMALIE LOCKS
BEECH I.
SQUAW PT.
JOHNSONS BAY
JOHNSONS PT.
THE SWALE
GOULDS PT.
RIDEAU RIVER AND CANAL
SMITHS FALLS
C.P.R.
C.P.C.
C.N.R.
425
43
15
29
LEGEND
26 - SAMPLING STATION Nº
C - CHEMICAL SAMPLE
P - PROFILE
CH - CHLOROPHYLL SAMPLE
1 3/4 1/2 1/4 0 1 MILES
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
LOWER RIDEAU LAKE
1971 WATER QUALITY SURVEY
SCALE: AS SHOWN
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CHECKED BY:
DRAWING Nº: 72-72-DE

of the shoreline is generally unsuitable for cottage development due to muck shore conditions.

Water Usage

The majority of the cottage owners use the lake water as their source of domestic supply. The lake supports recreational water sports such as fishing, boating, water skiing and swimming. According to information available from the Department of Lands and Forests the common game fish in this lake are northern pike, walleye, smallmouth and largemouth bass.

Waste and Refuse Disposal

The Town of Perth utilizes a three-celled waste stabilization pond for sewage treatment. The pond discharges to the Tay River downstream of Perth. The municipality has been progressing with a sewer separation program to upgrade the existing sewer system, however, bypassing occurs periodically in the spring months at several overflow points in the town. Smiths Falls is served by a primary treatment plant which discharges to the Rideau River downstream of the town and thus does not affect the water quality in Lower Rideau Lake.

The homes in the Rideau Ferry and Port Elmsley have private septic tank systems which are regulated by the local public health authorities.

There are two solid waste disposal sites in the area near Lower Rideau Lake. One site is near Perth on the southern half of Lot 28, Concession 10 and the other, which serves Port Elmsley, is located on Lot 13, Concession 7. Both of these sites, which are in North Elmsley Township, do not appear to be posing any pollution hazards to the lake.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

Water quality surveys were conducted from June 11 to 15, August 12 to 16 and from October 18 to 22. One off-shore station (26) and four near-shore sampling sites (1, 12, 16 & 23), which were adjacent to the major inlets and outlets, were chosen for biological and/or physical and chemical sampling (Figure 1).

Dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically and pH was measured with a portable pH meter. Daily, samples for chlorophyll analysis were collected in a 32-ounce bottle at Station 26, utilizing a composite sampler lowered through the euphotic zone (2X Secchi disc) and immediately preserved with 10-15 drops of a 2% $MgCO_3$ suspension.

Once per survey, a 32-ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected at Station 26. As well, the major inlets and outlets were sampled at least once per year. The mid-lake station was sampled using a composite sampler through the euphotic zone. At inlets and outlets, samples were collected from 1 meter of depth using a Kemmerer sampler.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus concentrations were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 litre samples were filtered through a 1.2 u membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths of 600 to 750 mu using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards & Thompson (1952).

Bacteriological Field and Laboratory Methods

Five-day intensive bacteriological surveys were completed in June, August and October on Lower Rideau Lake. Twenty-six surface stations were sampled daily, as well as one depth station (Station D26).

Surface samples were collected at a depth of one meter below the surface using sterile, autoclavable polycarbonate 250 ml bottles. Depth samples were collected one meter above the bottom using a modified "piggy back" sampler and sterile 237 ml evacuated rubber air syringes.

All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration technique (MF) (Standard Methods, 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC), fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. The "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing micro-organisms may also be present.

The coliform group is defined, according to Standard Methods, 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden-green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the *Escherichia coli* group,

closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid, gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on the lake can be grouped, by this method, into areas or groups of stations within the same

statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentration may be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analysis of variance program (ANOVA-CRE; Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed.

Both of these assumptions were checked on Lower Rideau Lake. The Bartlett's test was found to be non-significant and the data followed a normal distribution, hence the analysis of variance (F-test, Sokal, 1969) was calculated on all stations.

If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare

the grouped bacteriological data from the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

During all surveys, only minor temperature differences were apparent between surface and bottom waters (Figure 2a, 2b and 2c) indicating the effects of vertical mixing processes. Lower water temperatures were recorded in September than in June or August indicating autumnal cooling (Figure 2c). Uniform dissolved oxygen concentrations, with respect to depth, were evident with the exception of the extreme bottom waters (Figure 2b and 2c) which were low in oxygen during the August and October surveys. These low oxygen levels resulted from bacterial oxidation of organic matter, biological respiration and chemical oxidation.

pH, Total Alkalinity and Free Carbon Dioxide

The pH and total alkalinity values were indicative of relatively hard waters. Due to wind-induced vertical mixing processes, pH, total alkalinity and free carbon dioxide values were similar at both 1 meter below the surface and 1 meter above the sediments (Table 1). For example, on October 21 at Station 26, pH values at 1 and 4m were 8.3 and 8.2 respectively, while corresponding total alaklinity concentrations were 96 and 97 mg/l respectively. Related carbon dioxide values were 0.0 and 0.8 mg/l respectively. pH values during the August survey were as high as 8.8 and exceeded the criteria for public surface water supplies and recreational use. It is felt that pH values below 6.5 or above 8.3 could cause eye irritation to swimmers.

Hardness, Chloride, Conductivity and Iron

The hardness, chloride and conductivity data (Table 2) were consistent with each other indicating that no unusual mineral characteristics were present. The water is sufficiently hard that detergents containing phosphorus are desirable for washing purposes. If such detergents are used by cottagers, every effort

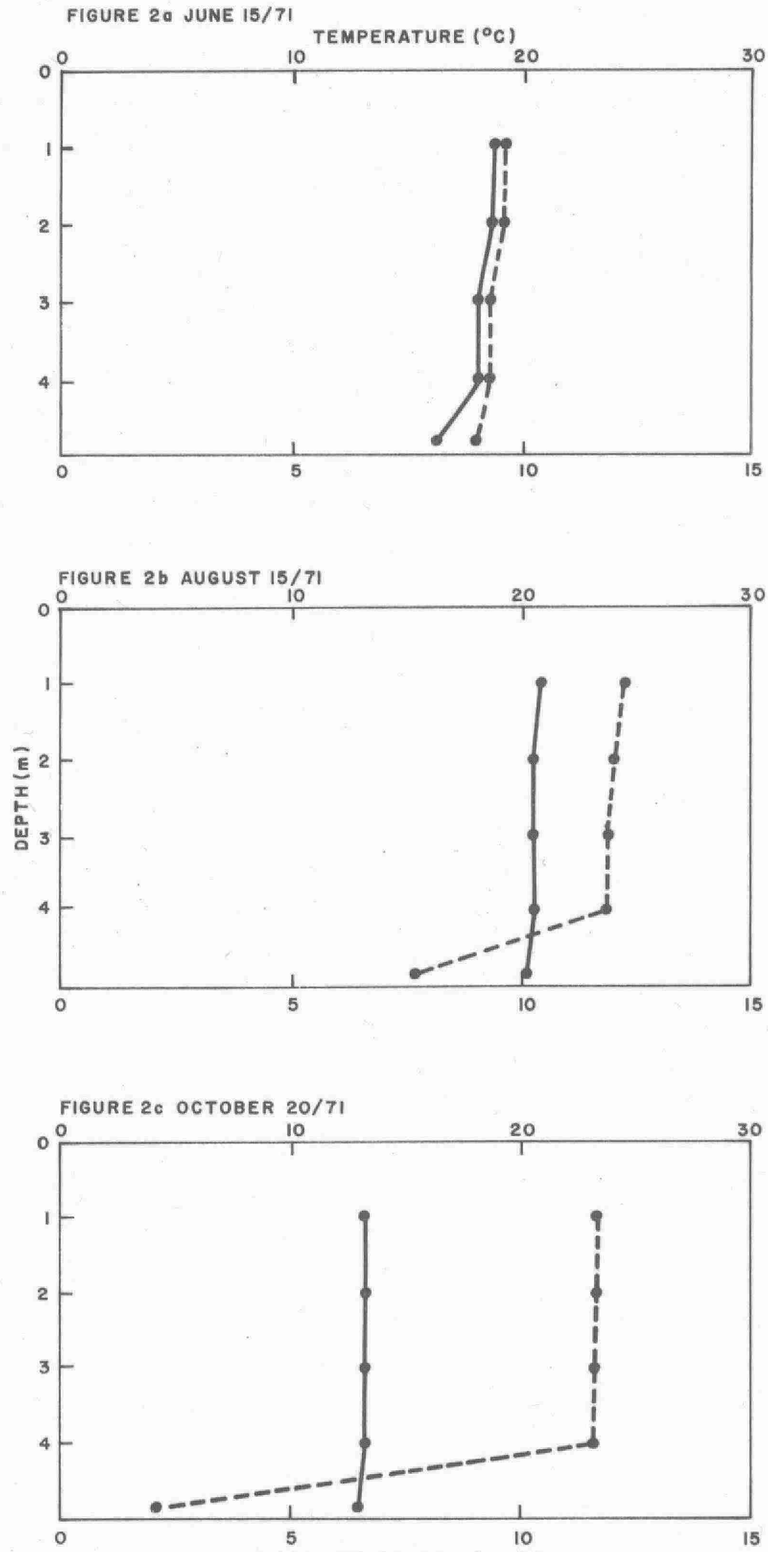

FIGURE 2: TEMPERATURE AND DISSOLVED OXYGEN PROFILE IN LOWER RIDEAU LAKE STATION 26

TEMPERATURE

DISSOLVED OXYGEN

should be made to ensure that the waste disposal system does not allow any phosphates to gain access to thelake.

The iron concentrations (Table 2) were uniformally low which is normal for this type of lake.

Kjeldahl Nitrogen and Total Phosphorus

The Kjeldahl nitrogen and total phosphorus concentration (Table 1) were characteristic of an enriched lake and can be expected to support nuisance levels of algae when growth conditions are favourable.

Chlorophyll a

Algal levels, as reflected by chlorophyll a concentrations were low (1.4 to 2.0 ug/l) to moderate (3.8 to 5.0 ug/l) for the June and October surveys respectively (Table 3). However, during August levels were as high as 16.0 ug/l. Such high algal densities severely reduce water quality for recreational activities and diminish the aesthetic quality of the lake.

As indicated earlier, chlorophyll a measures the amount of photosynthetic green pigment in algae while water clarity which is one of the more important parameters used in defining water quality is determined using a Secchi disc. Recently, Brown (1972) has indicated that a near-hyperbolic relationship exists between chlorophyll a concentrations and Secchi disc readings for lake of Precambrian origin. Figure 3 describes the author's mathematical relationship between chlorophyll a and Secchi disc for 945 sets of data collected from approximately sixty recreational lakes located primarily in southern Ontario. Points for eutrophic lakes which are characterized by high chlorophyll a concentrations and poor water clarity are situated along the vertical axis of the

FIGURE 3

CHLOROPHYLL a - SECCHI DISC RELATIONSHIP

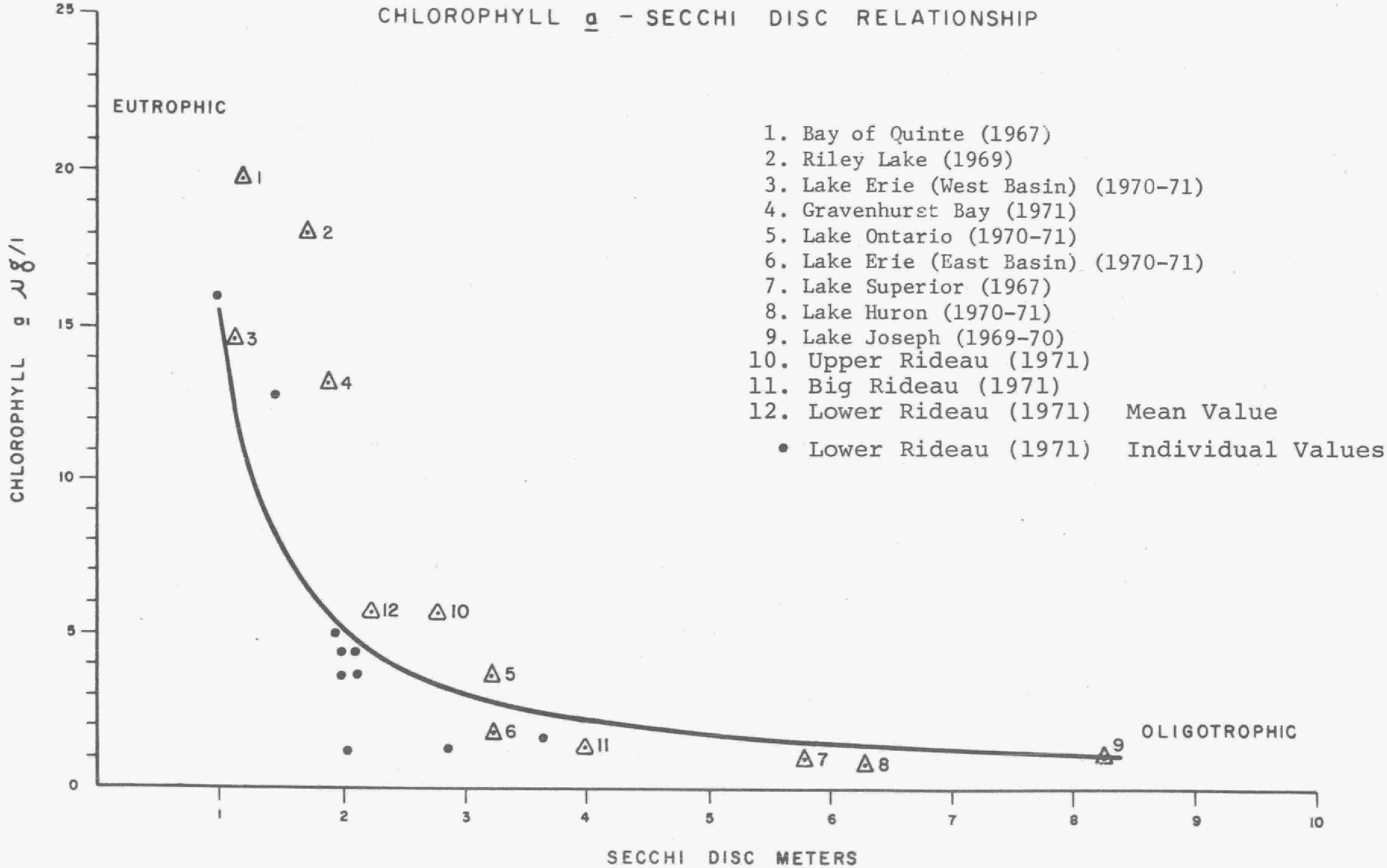

Figure 3: The relationship between chlorophyll a and Secchi disc as determined from the recreational lakes surveyed in 1971 - as well as the individual and overall mean values of chlorophyll a - Secchi disc for Lower Rideau Lake are presented. The values for the Great Lakes were added for comparative purposes.

hyperbola while oligotrophic waters which have low chlorophyll _a_ levels and allow significant light penetration be along the horizontal limb. Data for mesotrophic lakes could be dispersed about the middle section of the curve. The enriched status of Lower Rideau Lake is revealed by its midway position between values computed for the Bay of Quinte, the Western Basin of Lake Erie, Riley Lake and Gravenhurst Bay - four enriched or eutrophic bodies of water, and the oligotrophic to mesotrophic Lake Ontario and Eastern Basin of Lake Erie.

Submergent Aquatic Plants

Visual observations made during August of 1971 indicated that approximately 25% of Lower Rideau Lake supported dense beds of aquatic vegetation. Prominent plants included the milfoils - _Myriophyllum_ spp., the pondweeds - _Potamogeton_ spp., and tapegrass - _Vallisneria americana_.

Submersed aquatic plants when present in moderate quantities, play an important role in maintaining a balanced aquatic environment. Under favourable light, nutrient and substrate conditions, they provide a source of oxygen for the maintenance of all aquatic life, shelter and food for fish and fish-food organisms and spawning and nursery areas for many species of fish. Most naturally productive lakes such as Lower Rideau Lake having substantial growth beds of submergent leafy vegetation generally produce higher yields of warm-water species of fish such as walleye, bass and maskinonge than do the more deeper lakes of the Precambrian Shield. However, increased enrichment resulting from agricultural runoff, urbanization, and inadequate containment of cottage wastes have placed increasing stresses on these already productive lake systems. Artificial nutrient inputs have enhanced the production of aquatic plants to the point where many activities such as

swimming, water-skiing and unimpeded boating are practically impossible. Additionally, prolonged periods of hot, calm weather may periodically cause decomposition of aquatic plants in isolated bays where limited water exchange occurs and fish mortalities result. Finally, such lakes are susceptible to periodic winter kills of fish resulting from organic decomposition. It is certain that heavy densities of aquatic plants in many areas of the Province interfere with the harvest of game fish and it is a moot point whether or not existing conditions in Lower Rideau Lake actually favour or interfere with optimum game fish production.

Bacteriology

Lower Rideau Lake, during the three survey periods, was generally well within the OWRC criteria for total body contact recreational use (OWRC, 1970).

During the June survey the lake was homogeneous for TC and FC with overall geometric mean levels of 16 TC/100 ml, and 1 FC/100 ml. The FS concentrations over most of the lake, Group A, was 2 FS/100 ml (Figure 4). Group B, near the Town of Smiths Falls, with 16 FS/100 ml, Station 19, at the mouth of a bay with 8 FS/100 ml, and Station 23, near the locks on the southwest shore of the lake, with 5 FS/100 ml all had significantly higher FS means than Group A.

During the August survey the overall geometric mean bacterial levels for Group A were 12 TC/100 ml, 1 FS/100 ml and 5 FS/100 ml (Tables 4, 5 and 6, Figure 5). Group B (Stations 1 and 2), adjacent to Rideau Ferry with 48 TC/100 ml and Station 23 with 88 TC/100 ml had higher TC levels than Group A, while Station 21, 22 and D26 were significantly lower.

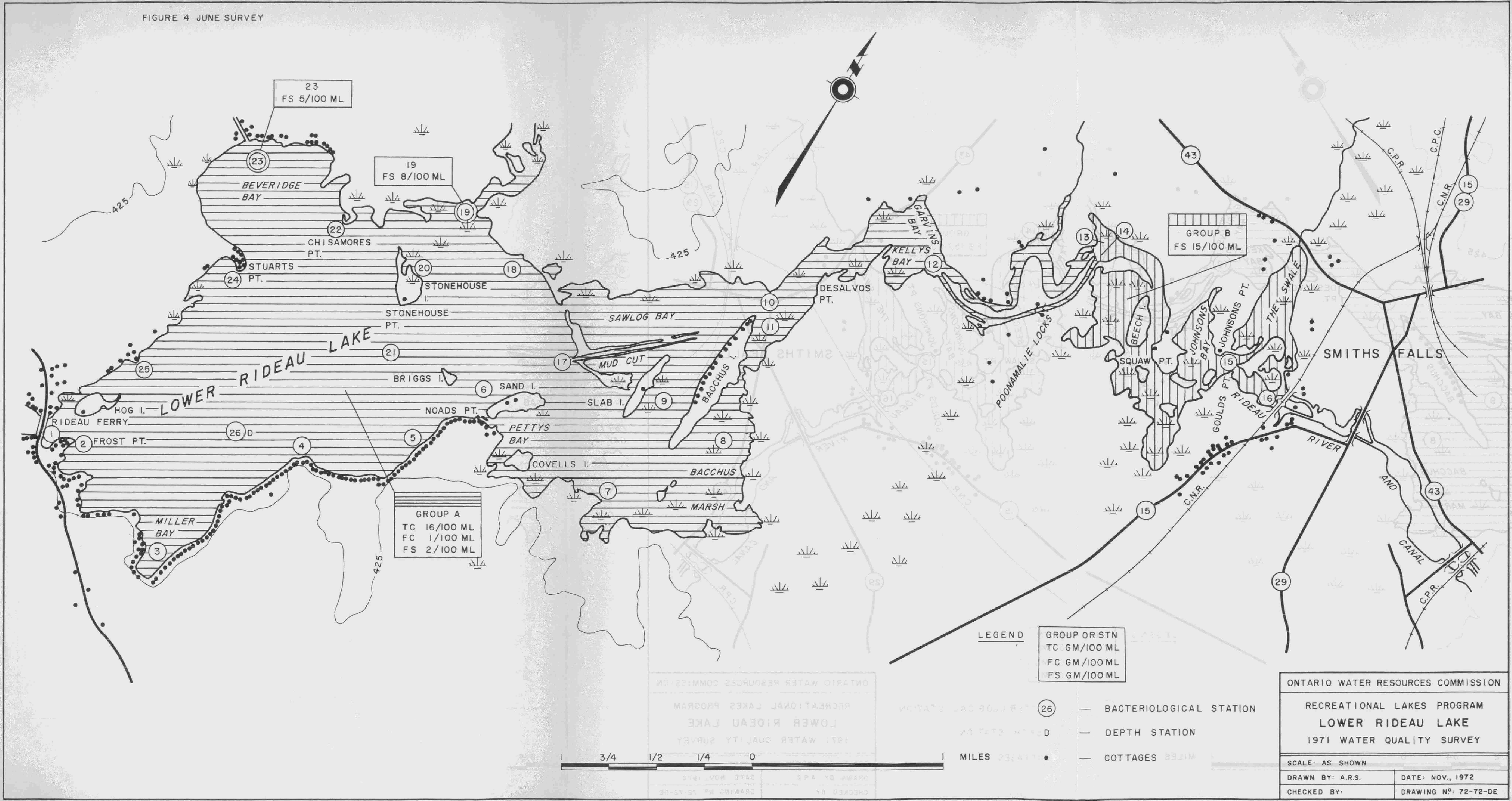
FIGURE 4 JUNE SURVEY
23
FS 5/100 ML
19
FS 8/100 ML
GROUP B
FS 15/100 ML
GROUP A
TC 16/100 ML
FC 1/100 ML
FS 2/100 ML
LOWER RIDEAU LAKE
BEVERIDGE BAY
CHISAMORES PT.
STUARTS PT.
STONEHOUSE I.
STONEHOUSE PT.
BRIGGS I.
SAND I.
SLAB I.
NOADS PT.
HOG I.
RIDEAU FERRY
FROST PT.
PETTYS BAY
COVELLS I.
MILLER BAY
SAWLOG BAY
MUD CUT
BACCHUS I.
BACCHUS MARSH
DESALVOS PT.
GARVINS BAY
KELLYS BAY
POONAMALIE LOCKS
BEECH
SQUAW PT.
JOHNSONS BAY
JOHNSONS PT.
THE SWALE
GOULDS PT.
RIDEAU RIVER AND CANAL
SMITHS FALLS
C.P.R.
C.N.R.
425
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
26 — BACTERIOLOGICAL STATION
D — DEPTH STATION
• — COTTAGES
1 3/4 1/2 1/4 0 1 MILES
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
LOWER RIDEAU LAKE
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SCALE: AS SHOWN
DRAWN BY: A.R.S.
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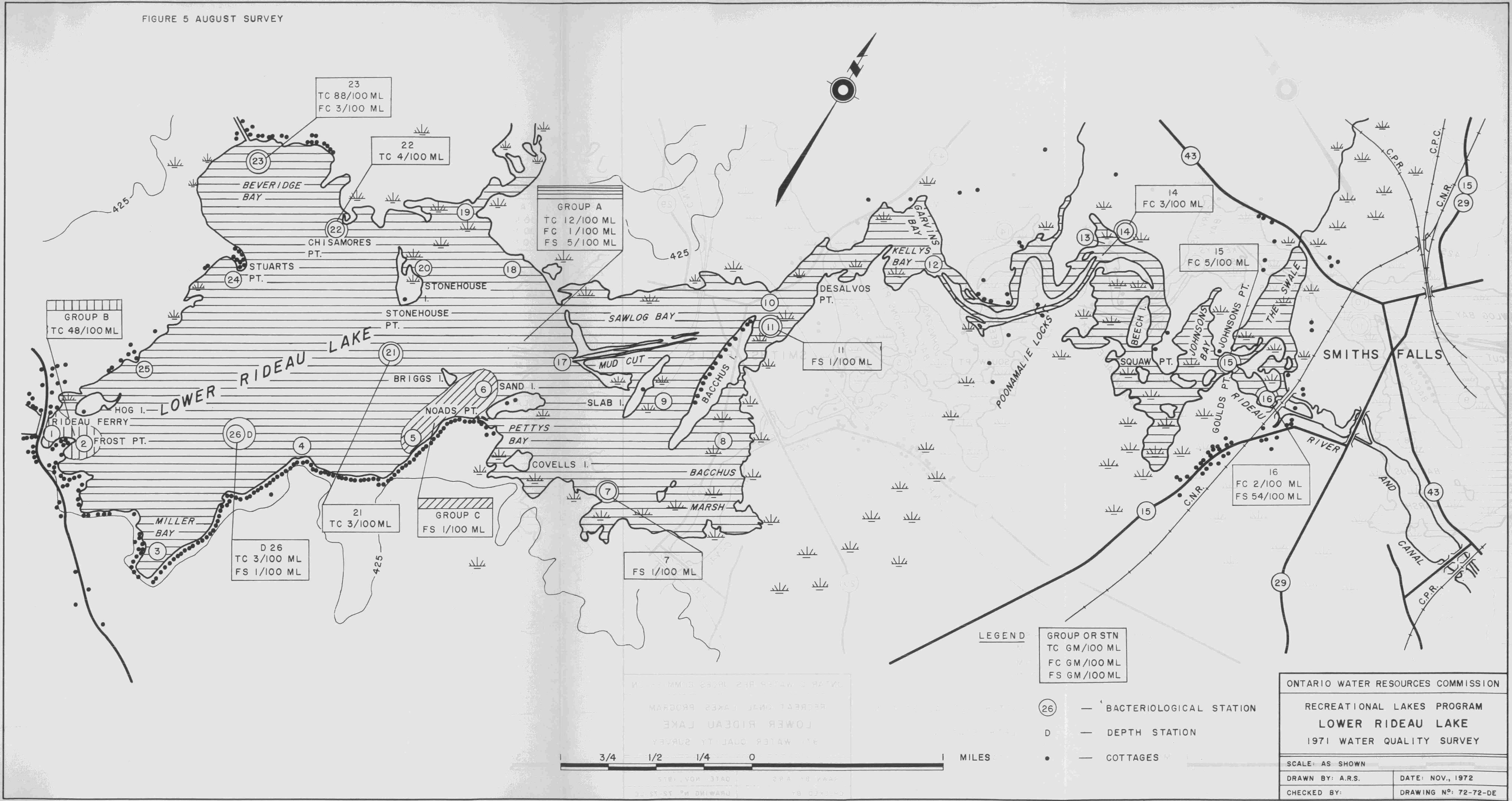
FIGURE 5 AUGUST SURVEY
23
TC 88/100 ML
FC 3/100 ML
22
TC 4/100 ML
GROUP A
TC 12/100 ML
FC 1/100 ML
FS 5/100 ML
GROUP B
TC 48/100 ML
GROUP C
FS 1/100 ML
21
TC 3/100 ML
D 26
TC 3/100 ML
FS 1/100 ML
7
FS 1/100 ML
11
FS 1/100 ML
14
FC 3/100 ML
15
FC 5/100 ML
16
FC 2/100 ML
FS 54/100 ML
BEVERIDGE BAY
CHISAMORES PT.
STUARTS PT.
STONEHOUSE I.
STONEHOUSE PT.
LOWER RIDEAU LAKE
BRIGGS I.
SAND I.
NOADS PT.
HOG I.
RIDEAU FERRY
FROST PT.
PETTYS BAY
COVELLS I.
MILLER BAY
SLAB I.
MUD CUT
SAWLOG BAY
BACCHUS I.
BACCHUS MARSH
DESALVOS PT.
KELLYS BAY
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POONAMALIE LOCKS
BEECH I.
SQUAW PT.
JOHNSONS BAY
JOHNSONS PT.
THE SWALE
GOULDS PT.
RIDEAU RIVER AND CANAL
SMITHS FALLS
C.P.R.
C.N.R.
C.P.C.
425
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
26 — BACTERIOLOGICAL STATION
D — DEPTH STATION
• — COTTAGES
3/4 1/2 1/4 0 1 MILES
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DRAWING No: 72-72-DE

FS concentrations at Stations 14, 15, 16 and 23 were slightly higher than Group A. Station 16 near Smiths Falls with a mean of 54 FS/100 ml exceeded the OWRC FS criteria while Stations 5, 6, 7, 11 and D26 had FS levels lower than Group A.

During the October survey (Figure 6) the entire lake was homogeneous for TC, FC and FS with overall geometric mean levels of 11 TC/100 ml, 1 FC/100 ml and 2 FS/100 ml except for Station 25 which had a lower TC mean of 3/100 ml.

Although Lower Rideau Lake had good bacteriological water quality, well within the recreational use criteria, no surface water is considered potable without prior treatment including disinfection.

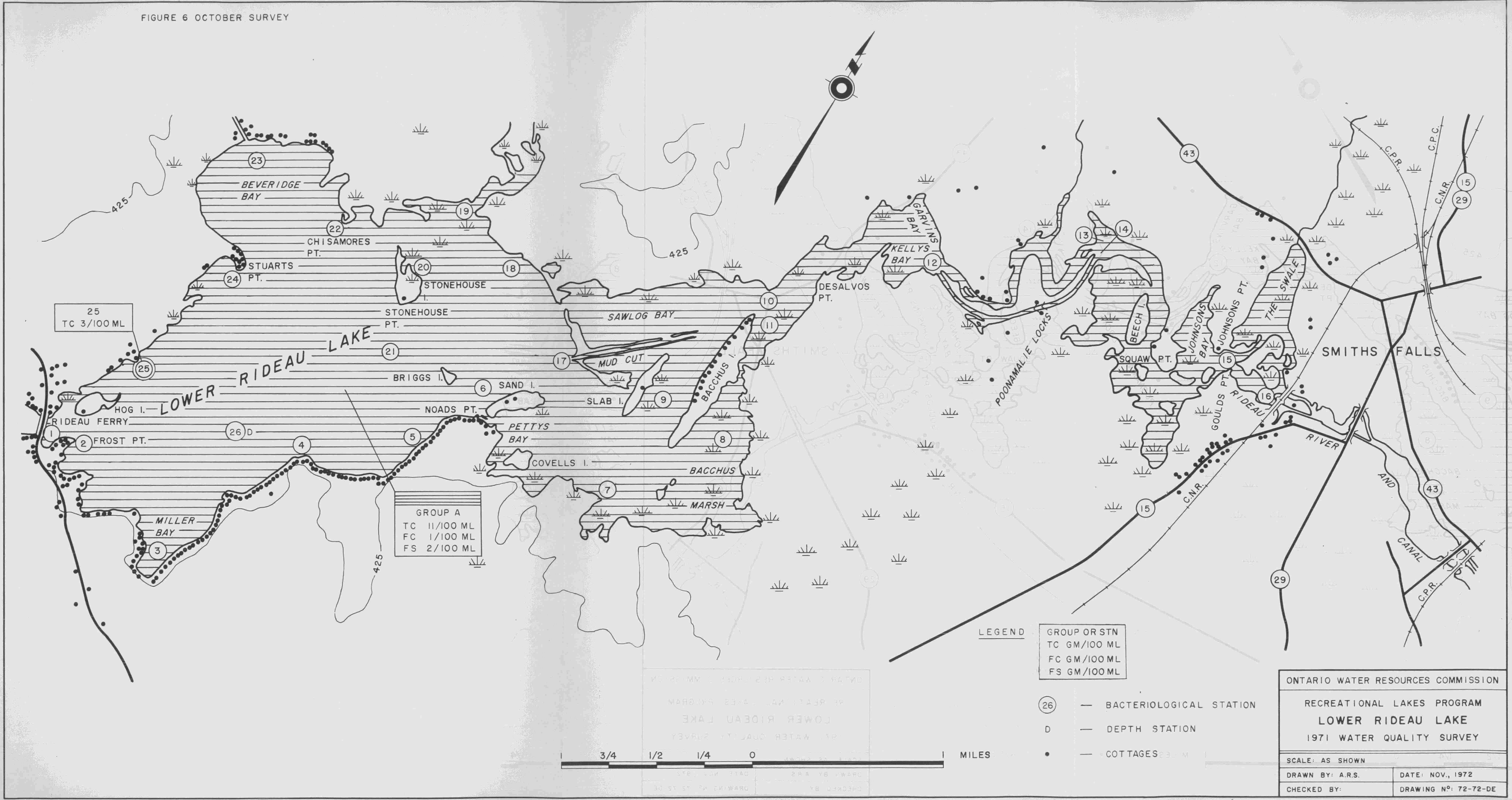


FIGURE 6 OCTOBER SURVEY
BEVERIDGE BAY
CHISAMORES PT.
STUARTS PT.
STONEHOUSE I.
STONEHOUSE PT.
25
TC 3/100 ML
LOWER RIDEAU LAKE
BRIGGS I.
SAND I.
HOG I.
RIDEAU FERRY
FROST PT.
NOADS PT.
PETTYS BAY
COVELLS I.
MILLER BAY
GROUP A
TC 11/100 ML
FC 1/100 ML
FS 2/100 ML
SAWLOG BAY
MUD CUT
SLAB I.
BACCHUS I.
BACCHUS MARSH
DESALVOS PT.
KELLYS BAY
GARVINS BAY
POONAMALIE LOCKS
BEECH I.
SQUAW PT.
JOHNSONS BAY
JOHNSONS PT.
THE SWALE
GOULDS PT.
RIDEAU RIVER
SMITHS FALLS
C.P.R.
C.P.C.
C.N.R.
AND CANAL
425
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
26 — BACTERIOLOGICAL STATION
D — DEPTH STATION
• — COTTAGES
1 3/4 1/2 1/4 0 1 MILES
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
LOWER RIDEAU LAKE
1971 WATER QUALITY SURVEY
SCALE: AS SHOWN
DRAWN BY: A.R.S.
DATE: NOV., 1972
CHECKED BY:
DRAWING No: 72-72-DE

Table 1

The ranges and means for pH, total alkalinity and free carbon dioxide at 1m and 1m above the sediments for Station 26 during 1971.

PARAMETER	DEPTH	RANGE	MEAN
pH	1m	8.1 - 8.6	8.37
	1m above bottom	8.1 - 8.8	8.35
Total Alkalinity	1m	76 - 117 mg/1	96.4 mg/1
	1m above bottom	89 - 117 mg/1	97.4 mg/1
Free Carbon Dioxide	1m	0 - 1.0 mg/1	0.1 mg/1
	1m above bottom	0 - 1.7 mg/1	0.34 mg/1

Table 2

Hardness (Hard), Iron, Total Phosphorus (P), Total Kjeldahl Nitrogen (N), Chloride (Cl) and Conductivity (Cond) for Lower Rideau, 1971

Results are expressed in mg/l except conductivity which is umhos/cm^3.

Station	Depth	Date	Iron	Hard.	P	N	Cl	Cond.
1	1m	11/6	0.05	106	0.030	0.45	5	212
1	1m	22/10	0.05	106	0.018	0.57	5	211
12	1m	22/10	0.05	100	0.020	0.63	6	206
16	1m	11/6	0.05	104	0.040	0.57	5	204
23	1m	22/10	0.15	106	0.032	0.56	6	216
26	5m comp	13/6	0.05	106	0.018	0.41	5	207
26	3m comp	15/8	0.15	122	0.036	0.20	4	202
26	4m	15/8	-	-	0.034	0.59	-	-
26	4m comp	22/10	0.05	100	0.030	0.66	5	206

"comp" means a composite sample taken through the depth indicated

Table 3

Chlorophyll a (µg/l) and Secchi Disc values (m) for Lower Rideau Lake, Station 26 during 1971.

Date	Chlorophyll a	S.D.
June 12	1.4 µg/l	2.8m
June 13	2.0	3.5
June 14	1.4	2.0
August 12	12.6	1.5
August 14	16.0	1.0
October 18	3.8	2.0
October 19	5.0	2.0
October 20	4.2	2.0
October 21	4.3	2.0
October 22	3.8	2.0
Mean	5.45	2.08

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F - the calculated analysis of variance statistic on F ratio.

df - degrees of freedom of the F ratio for "between group" and "within group" variation.

F(5%) - the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.

log GM - the logarithm (base 10) of the geometric mean.

S.E. - the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

N - the number of values in the mean.

GM - the geometric mean of the bacterial level.

t - the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

Table 4

Analysis of Variance Summary of Groups

Parameter - Total Coliform TC/100 ml

SURVEY	JUNE 11 - 15	AUGUST 12 - 16	OCTOBER 18 - 22
Group	Run 1 All Stations	All Stations	All Stations
F	1.277	2.976	1.928
df	26, 105	25, 102	15, 62
F5%	1.607	1.620	1.836
	NSD	SD	SD
Group	Total Lake	A	A
		All stations except 1, 2, 7, 21 - 23, D26	All stations except 25
F	1.277	1.5306	1.7094
df	26, 105	18, 76	14, 58
F5%	1.607	1.72	
	NSD	NSD	NSD
log GM	1.2009	1.0822	1.0532
SE	0.0579	0.0608	0.0601
N	132	95	73
GM	16	12	11
Group		B	Station 25
		Station 1, 2	
F		0.0277	
df		1, 8	
		NSD	
log GM		1.6811	0.4817
SE		0.1741	0.2950
N		10	5
GM		48	3
Group		Station 23	
log GM		1.9451	
SE		0.1606	
N		5	
GM		88	

Table 5

Analysis of Variance Summary of Groups

Parameter - Fecal Coliform FC/100 ml

SURVEY	JUNE 11 - 15	AUGUST 12 - 16	OCTOBER 18 - 22
Group	Run 1 Total Lake	Total Lake	Total Lake
F	1.438	4.044	0.0
df	26, 106	25, 102	15, 64
F5%	1.606	1.620	1.831
	NSD	SD	NSD
Group	Total Lake	A All stations except 14, 15, 16, 23	Total Lake
F	1.438	0.7094	0.0
df	26, 106	21, 81	15, 64
F5%	1.606	1.66	1.831
	NSD	NSD	NSD
log GM	0.0873	0.0205	0.0
SE	0.0209	0.0085	0.0
N	133	103	80
GM	1	1	1

Table 6

Analysis of Variance Summary of Groups

Parameter - Fecal Streptococcus FS/100 ml

SURVEY	JUNE 11 - 15	AUGUST 12 - 16	OCTOBER 18 -22
Group	Run 1 Total Lake	Total Lake	Total Lake
F	7.780	3.312	0.807
df	26, 106	25, 100	15, 64
F5%	1.606	1.622	1.831
	SD	SD	NSD
Group	A	A	A
	All station except 13 - 16, 19, 23	All stations except 5 - 7, 11, 16, D26	Total Lake
F	1.396	1.6959	0.807
df	20, 82	19, 78	15, 64
F5%	1.704	1.72	1.831
	NSD	NSD	NSD
log GM	0.1683	0.6677	0.1661
SE	0.0275	0.0693	0.0374
N	103	98	80
GM	2	5	2
Group	B	B	
	Station 13 - 16	Station 5, 6	
F	0.1194	1.000	
df	3, 16	1, 8	
F5%	3.24	5.32	
	NSD	NSD	
log GM	1.211	0.0301	
SE	0.1046	0.0301	
N	20	10	
GM	16	1	
Group	Station 19	Station 7	
log GM	0.8975	0.1204	
SE	0.1361	0.1204	
N	5	5	
GM	8	1	

GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL _a_	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

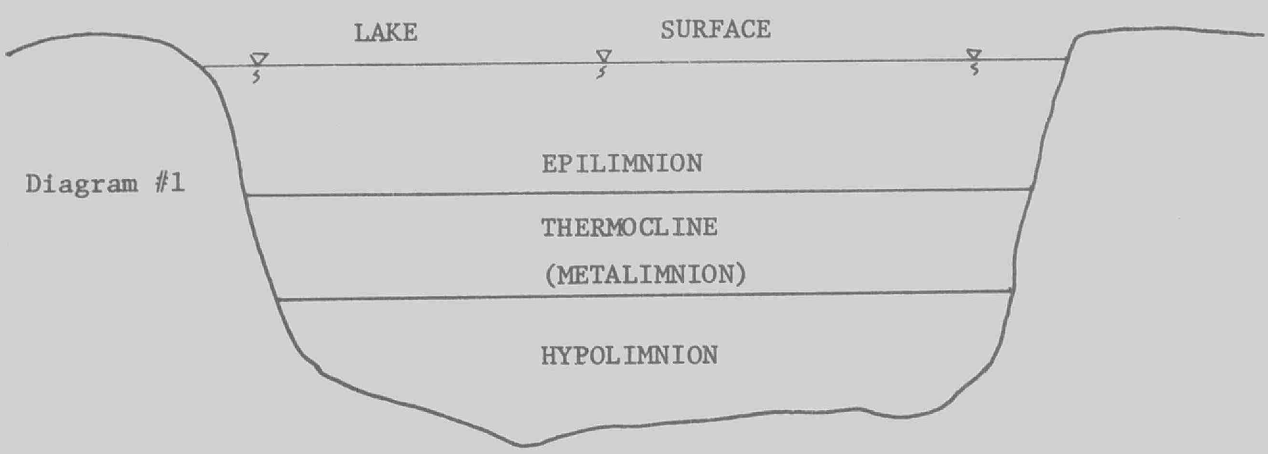
EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESOTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

SECCHI DISC :A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION :During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion) :The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding $1^{\circ}C$ increase per meter.

Diagram #1



TOTAL COLIFORMS (TC) :Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS :Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS
(continued)

:oligotrophic, mesotrophic and eutrophic. If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

BIBLIOGRAPHY

BENNETT, E.A. Taken from the Great Lakes as an Environment, Edited by D.V. Anderson, Great Lakes Institute Report PR 39, University of Toronto, October 1969

BROWN, D.J. 1971 Chlorophyll a - Secchi disc relationship in Ontario Recreational Lakes (In Preparation).

BURGER, A. Statistical Bacteria Data Summarization and Interpretation Internal OWRC Report (Unpublished).

EDMONDSON, W.R. 1970 Phosphorus, Nitrogen and Algae in Lake Washington after Diversion of Sewage. Science **169** No. 3946 : 690-691.

GELDREICH, E.E., BEST, L.C., KENNER, B.A., VAN DORSEL, D.J. The Bacteriological Aspects of Storm-water Pollution J. WPCF Vol. 40 No. II, Part I, 1968, pp. 1861-1872.

Guidelines and Criteria for Water Quality Management in Ontario, OWRC, June 1970

> <u>Microbiological Criteria</u>
> Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, throat, nose and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least 10 samples per month, including samples collected during weekend periods.

RICHARDS, F.A. and THOMPSON, T.G. 1952 The estimation and characterization of plankton populations by pigment analysis II. The spectrophotometric method for the estimation of plankton pigments. J. Marine Res., 11:156.

ROHLF, F.M. and SOKAL, R.R. 1969 Statistical Tables, W.H. Freeman and Company, San Francisco.

SOKAL, R.R. and ROHLF, F.J. 1969 Biometry, the principals and practices of statistics in biological research, W.H. Freeman and Company, San Francisco

Standard Methods for the Examination of Water and Wastewater, 13th Edition, 1971. APHA, AWWA, WPCF.